

# The MuCap Experiment: A Precision Measurement of Muon Capture in Hydrogen

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The goal of the MuCap experiment is to perform a high-precision measurement of the rate  $\Lambda_S$  for muon capture on the proton,  $(\mu p) \rightarrow n + \nu$ , by comparing muon lifetimes between the  $(\mu^- p)$  and free  $\mu^+$  systems. A 1%  $\Lambda_S$  measurement determines the least well known of the weak nucleonic charged current form factors, the induced pseudoscalar  $g_p$ , to 7%. Previous  $g_p$  measurements have yielded conflicting results, while recent theoretical advances have produced an accurate prediction for its value. By employing novel methods we hope to avoid the problematic uncertainties of earlier experiments and thereby resolve the longstanding confusion surrounding  $g_p$ .

MuCap made considerable progress towards its design goals during our 2004 experimental run at the Paul Scherrer Institut (PSI) in Switzerland. Among the developments:

- Muon detector improvements dramatically reduced beam scattering and nearly doubled the muon stopping efficiency from that observed in 2003.
- A new, second wire chamber was added to the electron detector assembly, allowing for full three-dimensional decay electron tracking. This capability is essential for suppressing background and studying the effects of deuterium contamination.
- A new “Continuous Hydrogen Ultra-Purification System” (CHUPS) was developed to continuously clean high-Z impurities from our hydrogen gas target. CHUPS was able to maintain impurity levels at 0.07 ppm, nearly an order-of-magnitude better than the 2003 level of 0.5 ppm. This is critical for suppressing distortions to the muon lifetime curve.
- New electronics and an upgraded data acquisition system increased the experiment’s reliability, data throughput, and livetime.

Figure 1 shows the complete 2004 experimental assembly.

From October–November 2004 we collected approximately  $2 \times 10^9$  good, pileup-protected  $\mu^-$  events. This represents MuCap’s first viable physics data under sustained clean conditions. Berkeley and UIUC are currently analyzing the 2004 data with plans for a 3%  $\Lambda_S$  result sometime in 2005.

The following final upgrades are anticipated for future MuCap runs:

- We plan to install an *in situ* moisture analyzer to actively monitor the ppb level of water vapor contamination in the hydrogen gas.

- Improvements to the time projection chamber (TPC), MuCap’s hydrogen gas-filled active target, should enable it to operate at increased voltages and thereby enhance its detection capabilities.
- The TPC will be fully instrumented with new FADC electronics, allowing for improved diagnostics regarding hydrogen gas impurities.
- The installation of neutron counters with pulse shape discrimination capabilities should facilitate studies of  $(\mu p)$  molecular processes, which contribute to systematic errors.
- The Muon-On-REquest (MORE) beamline system will enable an increased data collection rate.

With these advances we hope to collect the full  $10^{10}$  statistics for both  $\mu^-$  and  $\mu^+$  in 2005-2006.

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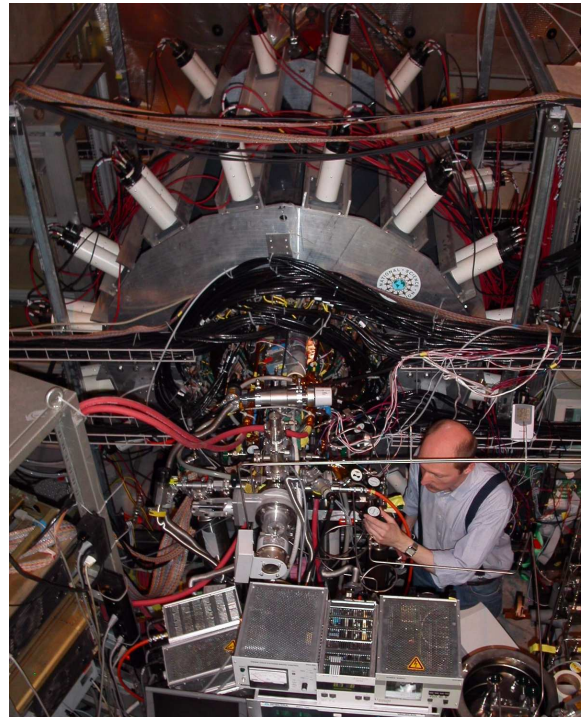


FIG. 1: Photograph of the 2004 MuCap experimental setup.